Los Alamos National Laboratory **Environmental Restoration Project** **Standard Operating Procedure**	No: LANL-ER-SOP-6.27 Rev: 0

SUBSURFACE VAPOR SAMPLING USING SOIL GAS PROBES AND SINGLE DOWNHOLE PACKERS

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide instructions for the collection of subsurface gas/vapor samples using soil gas probes and single downhole packers.

2.0 SCOPE

2.1 Applicability

This procedure is applicable for the collection of subsurface gas/vapor samples using soil gas probes and single downhole packers for the Los Alamos National Laboratory (Laboratory) Environmental Restoration (ER) Project. These methods are used at sites with volatile and semi volatile hazardous and radioactive contaminants.

2.2 Training

Field team members, including the Field Team Manager, Field Team Leader, Site Safety Officer, and sampler(s) performing subsurface gas/vapor sampling must document that they have read and understand this SOP and all procedures in Section 1.0 (General Instructions) of the Laboratory's ER SOPs.

3.0 DEFINITIONS

A. Soil Gas Probe: A device driven into the subsurface for the purpose of extracting subsurface gas/vapor for chemical analysis. The probe consists of sections of pipe equipped with a driving point, a sampling screen, and a Teflon sampling tube. The driving point is located at the base of the probe; the sampling screen is located between the driving point and probe pipe; and the sampling tube leads from the screen, up the inside of the pipe to the surface for the collection of gas/vapor from the subsurface. The tube is connected to the sampling screen which is sealed off from the upper sections of pipe.

B. Downhole Packer: An inflatable bladder that is placed in the annulus of the auger flights in a borehole or in an open section of a borehole to seal off a specific interval of the borehole for the purpose of sampling the pore gas/vapor in that interval. A compressed gas, such as nitrogen or zero air, is used to inflate the packer. The packer is equipped with a Teflon sampling tube leading from below the packer within the sampling interval to the ground surface for the collection of subsurface gas/vapor.

C. Zero Air: Compressed dry air containing less than 1 ppm total hydrocarbons.

D. SUMMA® Canister: An evacuated stainless steel sampling device with a passivated inner surface that resists both surface adsorption and chemical reaction. Evacuated canisters are used to draw in the gas/vapor sample and retain it for remote laboratory analysis.

E. Tedlar Bag: A dedicated gas/vapor sampling bag made of Tedlar film, a chemically inert fluorocarbon polymer with characteristically low permeability. The bag is received from the supplier in an evacuated and sealed condition.

F. Lung Box: A sealed rigid box used for collecting a gas/vapor sample in a Tedlar sample bag. An evacuated sample bag is placed into the lung box; then the air in the box is evacuated using a pump. A sample is collected in the bag by slowly opening the valve on the sample bag.

G. Sorbent Tube: A glass, metal, or plastic tube containing solid material specifically designed to adsorb analytes of interest. When gas/vapor is pulled through the tube, airborne chemicals are trapped by the adsorbent material. In some cases, tubes are equipped with a second layer of adsorbent material that serves as a backup layer and also indicator of sample breakthrough.

H. Sample Vial: An evacuated glass container with a butyl rubber septum, which allows sample collection using a needle. The sample is sealed off automatically by the rubber septum when the vial is removed from the needle.

I. Equipment Blank: A sample of zero or ambient air collected through a decontaminated soil gas probe or downhole packer. Equipment blanks are collected as a check on the adequacy of decontamination procedures.

J. Ambient Air Blank: A sample of ambient air taken, possibly in tandem with the equipment blank, to monitor for the presence of compounds found in the ambient air at the field site. The ambient air blank is equivalent to a field blank.

K. Pore Gas/Vapor: Gaseous or vapor phrase compounds contained within the interstitial spaces of soil. Gas refers to a compound that is normally in the gaseous state at room temperature, while vapor refers to compounds that are normally liquids at room temperature but possess significant vapor pressures.

L. Volatile Compounds: Compounds having vapor pressures at 25°C greater than 10^{-1} mm Hg (EPA, 1988).

M. Semi volatile Compounds: Compounds having vapor pressures at 25°C between 10^{-1} and 10^{-7} mm Hg (EPA, 1988).

N. Holding Time: Time between sampling and analysis that should not be exceeded in order to prevent sample deterioration.

O. Lag Time: Time between sample collection and analysis determined by availability and proximity of analytical equipment. Lag time differs from holding time in that holding times are controlled by the analytes and lag times are controlled by the availability and proximity of analytical equipment.

4.0 BACKGROUND AND CAUTIONS

4.1 Background

The use of soil gas probes and downhole packers to collect subsurface pore gas/vapor samples is applicable to sites with volatile, semivolatile, hazardous, and radioactive contamination. The method of subsurface vapor sampling used depends on the site characteristics and the scope of the sampling plan.

- Soil gas probes are good for shallow (< 15 ft below ground surface) in soil, sediment, and soft rock.

- Downhole packers are appropriate for use in boreholes and thus are good for sampling greater depths in a wider variety and hardness of materials. However, use of a downhole packer does require the advancement of a borehole with a drill rig.

  For the purpose of this SOP, downhole packers are used during the advancement of a borehole using a hollow-stem auger rig. The theory behind the technique is that the cuttings along the auger flights create a seal, and therefore, a representative sample can be collected from the base of the borehole. With the augers in place, a packer is placed at a known depth near the base of a borehole, where it is inflated to seal off a small sampling interval below the inflated packer. The packer is equipped with two sets of tubing which run from the packer to the surface. One set of tubing is used to inflate the packer with an inert gas such as zero air or nitrogen. The other tubing is Teflon and is used for the sample collection; it runs from the sampling interval below the inflated packer to the surface.

  The type of container used depends on the target analytes and lag time before analysis. The allowable holding times for the target analytes should be determined before sampling begins so that appropriate arrangements can be made with laboratories and shippers.

- SUMMA canisters are appropriate for collecting volatile and semivolatile compounds (See EPA, 1988 for a complete list) that are going to be shipped to a laboratory for analysis. Each canister is equipped with a pressure gauge and a tag that are used to monitor for canister volume loss. Samples are not valid if a loss of > 2 psi (7%) is determined. If the concentrations of gas in a canister are high or the potential for radioactive gases/vapors exists, there may be shipping and/or laboratory restrictions. The allowable holding times for target analytes should be determined prior to sampling so that arrangements can be made with the laboratory.

- Tedlar bags and sample vials are appropriate for collecting volatile and semivolatile gas/vapor samples that will not be subjected to a significant lag time before analysis. The use of Tedlar bags or sample vials is appropriate when field analysis equipment or a nearby laboratory are available. Sample vials are particularly useful for sampling in conjunction with soil-vapor extraction pilot tests.

  The holding times for these containers may vary, depending on the analyte of interest, and should be determined in coordination with the analytical laboratory prior to sample collection. However, the samples are subject to loss over time, so analysis should be completed within 8 hours after collection.

- Sorbent tubes are useful when the specific analytes of interest are known. The type of sorbent material used is controlled by the specific analytes of interest:

  - Volatile, nonpolar organics (e.g., aromatic hydrocarbons, chlorinated hydrocarbons) having boiling points in the range of 80°C to 200°C can be collected in Tenax™ resin tubes.
  - Aliphatic amines and tritium should be collected using silica gel tubes.
  - Aldehydes and ketones should be collected with XAD-2 tubes.

  Holding time depend on target analytic and should be determined in coordination with the analytical laboratory prior to sampling. Sorbent tubes should be kept in iced coolers while awaiting analysis in accordance with manufacturer instructions.

4.2 Cautions

A. Keep all sample containers out of direct sunlight and at ambient temperatures (unless otherwise stated) before and after sample collection.

B. Make sure all fittings are tight, for they will tend to loosen during the driving process. Wrap all fitting threads with nonadhesive Teflon tape.

C. Make shipping and laboratory personnel aware of all container-specific holding time restrictions as well as holding time requirements. The site-specific sampling and analysis plan should identify and coordinate all these issues.

D. Use direct-reading instruments (with soil gas probes and downhole packers to assess contaminant concentrations on a real-time basis. The use of direct-reading instruments is essential for field health and safety monitoring of hazardous and radioactive constituents. The analytical laboratory will use the direct reading instrument data to ensure their own health and safety and to assist in selecting an appropriate calibration range for their instruments.

E. If a generator is used to power a driver, place the generator exhaust downwind of the probe in order to not contaminate the samples.

5.0 EQUIPMENT

Equipment and materials necessary for performing subsurface gas/vapor sampling using soil gas probes and downhole packers include, but are not limited to, the following:

- Soil gas probe [Art's Manufacturing Supply (AMS) Soil Gas Probe Kit # 209.86 or equivalent]
- Soil gas probe driver (manual or power)
- Generator to run power driver (if used)
- Mechanical high-lift jack for removing soil gas probe (comes with AMS Probe Kit)
- Downhole packer system, including rubber bladder with Teflon sampling tubing, inflation tubing, sampling port, safety cable, and reel for tubing/cable (Science and Engineering Associates packer system or equivalent)
- Sample containers
  - SUMMA® canisters with valves and pressure gauge
  - Tedlar bags with valves and lung box
  - Sorbent tubes with appropriate compression fittings
  - Sample vials (125 mL Pyrex glass serum vials with butyl rubber septa), disposable syringes (60 mL), and 20-22 gauge needles
- Three-way, luer-tipped valves
- Compressed dry nitrogen (Ultra-high purity grade) or zero air supply
- Vacuum pump and rotameter, or calibrated sampling pump
- Hand pump for evacuating lung box
- Sample coolers (with ice if required)
- PID, FID, or appropriate monitoring instrument
- Decontamination equipment, solutions, and chemicals
- Field documentation and support equipment.

6.0 PROCEDURE

6.1 Soil Gas Probe Preparation and Installation/Use

6.1.1 Preparation

A. Prepare a decontaminated probe by first attaching the Teflon sampling tubing to the screen near the driving point of the first probe section. Make sure enough tubing has been attached to reach the deepest desired sampling depth. Thread the sample tubing through the probe and attach a blunt driving head to the top of the first probe section; the sample tubing should extend out a slot in the driving head to protect it during installation.

B. Place a decontaminated, removable (or disposable) stainless steel (or appropriate material) drive point on the end of the first section of probe.

6.1.2 Installation and Operation

A. Drive the probe to the desired depth with a manual or power pipe driver, adding sections as necessary. Sections of probe are added by removing the driving head, threading the sample tubing through a new section, attaching the driving head to the new section as in Section 6.1.1, Step A. While driving in the probe, take care not to enlarge the hole unnecessarily by lateral probe movement.

B. When the screen is at the appropriate sample depth, attach a high-lift jack to the probe and lift up the probe out of the access hole about 1/2 in. to separate the driving tip from the probe. Doing this exposes the screen and provides a pathway for subsurface pore gas/vapor to enter the sample tubing.

C. Remove the blunt driver tip from the probe and attach a luer-tipped, three-way valve and connectors to the Teflon tubing. Seal the top of the annular space between the probe and the surface soil/formation with an appropriate impermeable material (e.g., bentonite, soil, molding clay, etc).

D. Connect an appropriate monitoring instrument to one port on the three-way valve. On the remaining valve port, connect the vacuum pump and rotameter or calibrated sampling pump. Open the three-way valve to the pump and purge a minimum of one sample tube volume, not exceeding the volume at which concentrations of the subsurface gas/vapor begin to drop off.

NOTE: During the purging process, it is necessary to monitor the breathing zone to ensure that personnel are not exposed to subsurface gas/vapor.

E. Monitor the concentration of the subsurface gas/vapor at set (e.g., 1-min) intervals by switching the three-way valve from the pump connection to the monitoring instrument.

F. Record in a field book all installation and purging details, including tube volume, pumping rate, start and finish time of purging, volume purged, and gas/vapor concentrations in the subsurface obtained from the monitoring equipment.

G. When purging is complete, seal off the three-way valve to the subsurface awaiting sample collection. If the valve does not have an OFF position, then switch the valve to the monitoring instrument.

H. Remove the vacuum pump with rotameter or calibrated sampling pump from the three-way valve port in preparation for sample collection. The monitoring instrument should remain attached. If the probe is going to be advanced to greater depths for additional samples refer back to A.

I. If the probe will be advanced for further sample collection, refer back to step A above. Otherwise, remove the probe one section at a time using the jack. Remove the probe carefully; the probe tip and screen can be easily damaged.

6.2 Downhole Packer Installation and Use

6.2.1 Installation

A. Using a hollow-stem auger, advance the auger string and sample barrel to the desired sampling depth.

B. Remove the sample barrel from the auger string. The driller should take care not to clean the hole prior to gas sampling to ensure that the auger flights are filled with cuttings, effectively sealing off the bottom of the hole.

C. Insert the packer into the auger string and seat it against the sample barrel landing ring (located inside the auger bit).

D. Inflate the packer with compressed zero air or nitrogen, taking care not to over inflate and burst the packer.

E. Attach a three-way, luer-tipped valve to the surface end of the Teflon sample tubing.

F. Connect an appropriate monitoring instrument to one port on the three-way valve. On the remaining port, connect the vacuum pump and rotameter or calibrated sampling pump.

6.2.2 Use

A. Open the three-way valve to the pump and purge subsurface gas/vapor. The gas/vapor purged should equal, at a minimum, one sample tube in volume not exceeding the volume at which concentrations of the subsurface gas/vapor begin to drop off.

NOTE: During the purging process, it is necessary to monitor the breathing zone to ensure that personnel are not exposed to subsurface gas/vapor.

B. Monitor the concentration of the subsurface gas/vapor at set (e.g., 1-min) intervals by switching the three-way valve from the pump connection to the monitoring instrument.

C. Record in a field logbook all installation and purging details, including tube volume, pumping rate, start and finish time of purging, volume purged, and gas/vapor concentrations in the subsurface obtained from the monitoring equipment.

D. When purging is complete, seal off the three-way valve to the subsurface. Detach the vacuum pump with rotameter or calibrated sampling pump from the valve in preparation for sample collection (Section 6.3). The monitoring instrument should remain attached to the three-way valve.

E. If the borehole will be advanced for further sampling, refer to the process outlined above. Otherwise, deflate the packer and remove it from the borehole.

F. After removal and before reuse, decontaminate the exterior of the packer (Section 6.4).

6.3 Sample Collection

The following procedures for sample collection in Tedlar bags, SUMMA® canisters, sorbent tubes, and sample vials apply to both the soil gas probe and downhole packer sampling techniques.

6.3.1 Tedlar Bag and Lung Box

A. While preparing to sample, prepare to take readings from the monitoring instrument attached to the three-way valve during preset time intervals until the sample is collected.

B. Insert an evacuated Tedlar bag into the lung box and close and seal the lung box.

C. Attach the Tedlar bag in the lung box to the available port on the three-way valve.

D. Evacuate the lung box using a hand pump (or equivalent).

E. Switch the three-way valve to the port attached to the Tedlar bag. Slowly open the valve on the sample bag; the vacuum in the lung box will fill the Tedlar bag with subsurface gas/vapor. Do not overfill the Tedlar bag, for it may burst; a window on the lung box allows for visual observation of the Tedlar bag.

F. After the sample is collected, shut the valve on the Tedlar bag, and switch the three-way valve so that the subsurface is sealed from the atmosphere. Remove the Tedlar bag from the lung box and transfer it to a sample cooler (kept at ambient temperatures) to wait analysis.

G. Record in a field logbook all details of the sampling, including
- sampling date,
- time,
- ambient air temperature, and
- subsurface vapor/gas concentrations from the monitoring equipment.

6.3.2 Sorbent Tube

A. While preparing to sample, prepare to take readings from the monitoring instrument attached to the three-way valve at preset time intervals until the sample is collected.

B. Place the sorbent tube specific to the analyte(s) of interest in line between a vacuum pump with rotameter or calibrated sampling pump and the three-way valve. Attach the sorbent tube to the pump and three-way valve using the appropriate compression fittings make sure fittings are tight to avoid leakage, which should be stainless steel or Teflon.

C. Open the three-way valve to the port attached to the sorbent tube and pump. Turn on the pump and allow subsurface pore gas/vapor to run through the sorbent tube until the required volume has passed through the tube. The required sample volume is determined by the detection limit of the analytical method and should be outlined in the site-specific sampling and analysis plan.

D. After sample collection, turn off the pump, switch the three-way valve so that the subsurface is sealed off from the atmosphere. Remove the sorbent tube, cap the ends of the fittings, and transfer to a sample cooler to await analysis.

E. Record in a field logbook all details of the sampling including,
- sampling date,
- time,
- sample volume extracted (calculated from rotameter and sampling time),
- ambient air temperature, and
- subsurface gas/vapor concentrations from the monitoring equipment.

6.3.3 SUMMA® Canister

A. While preparing to sample, prepare to take readings from the monitoring instrument attached to the three-way valve at preset time intervals until the sample is collected.

B. Prepare the SUMMA® canister following instructions in LANL-ER-SOP-06.22, Canister Sampling for Organics, EPA Method T0-14.

C. Detach the purging pump and attach a SUMMA® canister to the available port on the three-way valve. Record in a field book the starting vacuum in the canister from the canister pressure gauge.

D. Open the three-way valve to the port attached to the SUMMA® canister. Slowly open the valve on the canister itself and allow the vacuum in the canister to draw in subsurface gas/vapor. Sample collection is complete when the pressure in the canister equilibrates with the subsurface conditions. (i.e., when the canister pressure gauge reading stabilizes).

E. After sample collection is complete, close the valve on the canister and switch the three-way valve so that the subsurface is sealed off from the atmosphere. Record in a field book the ending canister pressure from the canister pressure gauge. The canister can now be prepared for shipping to the laboratory for analysis.

F. Record in a field logbook all details of the sampling, including
- sampling date,
- time,
- ambient air temperature,
- starting and ending canister pressures, and
- subsurface gas/vapor concentrations from monitoring equipment.

G. The starting and ending canisters pressures should be recorded on the chain-of-custody form that accompanies the canister to the laboratory.

6.3.4 Sample Vial

A. While preparing to sample, prepare to take readings from the monitoring instrument at preset time intervals until the sample is collected.

B. Attach an additional luer-tipped, three-way valve to the available port on the original three-way valve [valve (a) on Attachment A] [valve (b) on Attachment A].

C. Connect a disposable syringe to one port on valve (b).

D. Connect a clean, stainless steel, 20-22 gauge needle to the remaining port on valve (b).

E. Attach an evacuated sampling vial to valve (b) by pushing the vial onto the needle attached in step D; valve (b) should be closed off to valve (a). Switch valve (a) from the monitoring instrument to valve (b) [Attachment A, position 1].

F. Open valve (b) to the sampling vial to allow subsurface gas/vapor to enter [Attachment A, position 2].

G. Open valve (b) to the syringe and draw in 60 mL of gas/vapor into the syringe. [Attachment A, position 3].

H. Switch valve (b) so that the sample vial is open to the syringe port. Pressurize the sample vial with 20 mL of gas/vapor from the syringe. [Attachment A, position 4]. Remove the sample vial and place into a cooler (at ambient conditions) to await analysis.

I. Switch the three-way valve (a) so that the subsurface is sealed off from the atmosphere at the conclusion of sampling.

J. Record in a field logbook all details of the sampling, including
- sampling date,
- time,
- ambient air temperature, and
- subsurface gas/vapor concentrations from the monitoring equipment.

6.4 Equipment Decontamination

6.4.1 Soil Gas Probe

This process applies to all reusable parts of the soil gas probe and must be performed between sampling locations.

A. Screen the equipment for radioactive contamination. If radioactivity is detected, implement the dry decontamination outlined in LANL-ER-SOP-01.08, Field Decontamination of Drilling and Sampling Equipment.

B. Once the equipment is determined to be free of any radioactive contamination, use the following chemical decontamination process:

1. Wash the equipment with a Liquinox® or Alconox® and water solution. A 5-ft-long barrel cleaning brush is helpful for cleaning the inside the probe pipe.

2. Rinse the equipment using potable water and air dry.

3. Provide a final rinse with deionized water and allow to air dry before resuse.

C. Segregate, contain, and dispose of all solutions produced during the decontamination process using approved waste management procedures. Following the collection of each sample, dispose of any disposable sampling equipment (e.g., syringes, needles, fittings, etc.) according to correct waste management procedures.

D. The method for decontaminating the Teflon tubing is found in Section 6.4.3 below.

6.4.2 Downhole Packer

The downhole packer is removed from the borehole between sampling intervals in the same sample locations. Before reuse, the outside of the packer and all tubing that runs down the auger string should be decontaminated in the following manner to prevent any cross-contamination.

A. Screen the equipment for radioactive contamination. If radioactivity is detected, implement the dry decontamination outlined in LANL-ER-SOP-01.08.

B. Once the equipment is determined to be free of any radioactive contamination, use the following chemical decontamination process:

1. Wash the outside of the equipment with a Liquinox® or Alconox® and water solution.

2. Rinse the equipment using deionized water.

3. Allow the equipment to air dry.

C. While decontaminating the outside of the equipment, take care not to allow any decontamination solution or water to enter the Teflon sample tubing.

D. Segregate, contain, and dispose of all solutions produced during the decontamination process using approved waste management procedures.

E. The method for decontaminating the Teflon tubing is found in Section 6.4.3 below.

6.4.3 Teflon Tubing

All used Teflon sample tubing should be decontaminated in the following manner:

A. After removal from the sample location, run nitrogen or zero air (or ambient air if the relative humidity is low) through the tubing to evacuate any residual subsurface gas/vapor. Because Teflon is a nonabsorbent material, liquid decontamination of the interior surface before reuse is not necessary.

B. Use a PID, FID, or appropriate monitoring instrument to ensure that the tubing is contaminant-free. If possible, also remove any visible material on the outside of the tubing. Dispose of and replace any tubing that is visibly damaged or contaminated or that equipment blanks show to be contaminated.

C. The fittings associated with the tubing should be stainless steel or Teflon. If the fittings are Teflon, treat them in the same manner as the tubing; if they are stainless steel, decontaminate them in the same method they can be decontaminated using the four-step process in Section 6.4.1. If the fittings become damaged, dispose of them and replace them with equivalent parts.

6.5 Quality Assurance/Quality Control Sampling

The following types of field quality assurance/quality control (QA/QC) samples are required. Establish analytical standards with the participating laboratory prior to sampling to ensure accuracy.

Duplicate Samples: Duplicate samples are used to check the precision of the analysis. They should be taken in the same manner as the regular samples, with a frequency of one duplicate per 20 samples or, at least, one duplicate per field sampling event.

Equipment Blank: An equipment blank, consisting of an appropriate sample container filled with zero air from a decontaminated soil gas probe or downhole packer before its use or reuse, should be collected at a frequency of one per day to check the decontamination process.

Ambient Air Blank: An ambient air blank, consisting of an appropriate sample container filled with ambient surface air, should be collected in tandem with the equipment blank at a frequency of one per day. These samples, equivalent to a field blank, assess the ambient surface air conditions and their potential interference's.

Trip Blank: A trip blank, consisting of an appropriate sample container filled directly with zero air, should be collected at a frequency of one per day. It should be stored and transported under the same conditions and in the same container (e.g., a cooler) as the rest of the samples for that day. Trip blanks are used to assess any potential contaminants introduced during sample transport.

7.0 REFERENCES

LANL-ER-SOPs in Section 1.0, General Instructions.
LANL-ER-SOP-06.21, Volatile Organic Sampling Train.
LANL-ER-SOP-06.22, Canister Sampling for Organics - EPA Method TO-14.

EPA, May 1988. Compendium Method TO-14 "The Determination of Volatile Organic Compound in Ambient Air Using SUMMA® Passivated Canister Sampling and Gas Chromatograph Analysis".

Posner, Judd C., and Woodfin, W. James: Sampling with gas bags I: losses of analyte with time. *Appl. Ind. Hyg. (1)4* (November 1986).

8.0 RECORDS

The following records are generated during sampling under this procedure

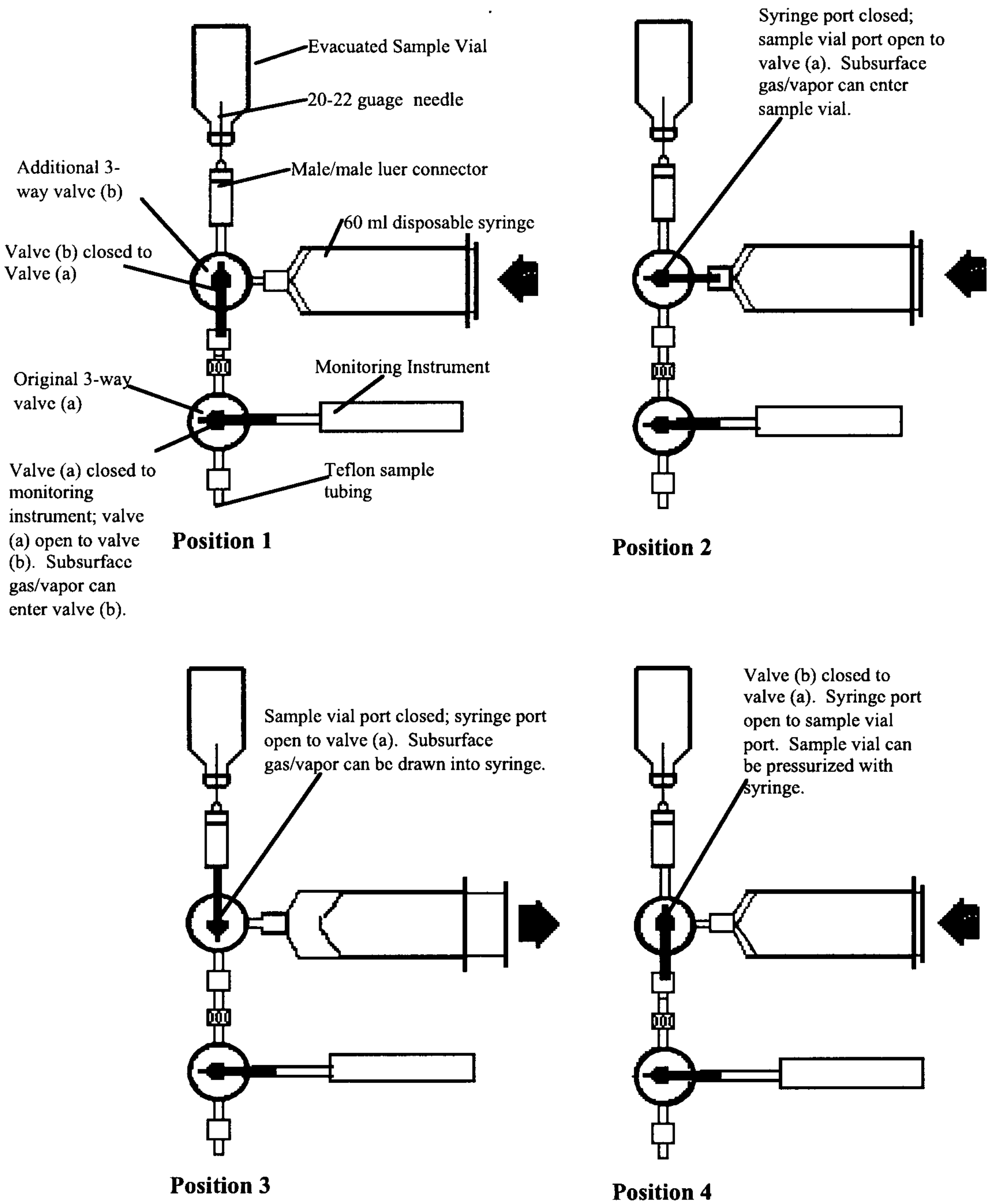
- Chain of Custody/Request for Analysis Forms.
- Sample Collection Log Forms.
- Daily Activity Log in the form of a field book that contains details on all sampling and field activities, including any pertinent field data.

The field leader is responsible for transferring these to the ER Records Processing Facility.

9.0 ATTACHMENT

Attachment A — Three-Way Valve Positions For Sampling System

Los Alamos National Laboratory Environmental Restoration Project
THREE-WAY VALVE POSITIONS FOR SAMPLING SYSTEM



The three-way valve pictured is generic. Individual valves may operate differently, and operators of the equipment should be familiar with the proper positioning of the valve to direct the gas/vapor in the necessary directions.